# GUIDE TO THE

# THIRTY-FOURTH ANNUAL FIELD CONFERENCE

# OF THE

# SECTION OF GEOLOGY

# OF THE

# OHIO ACADEMY OF SCIENCE

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# GEOLOGY OF THE COLUMBUS - GALENA - GAHANNA AREA

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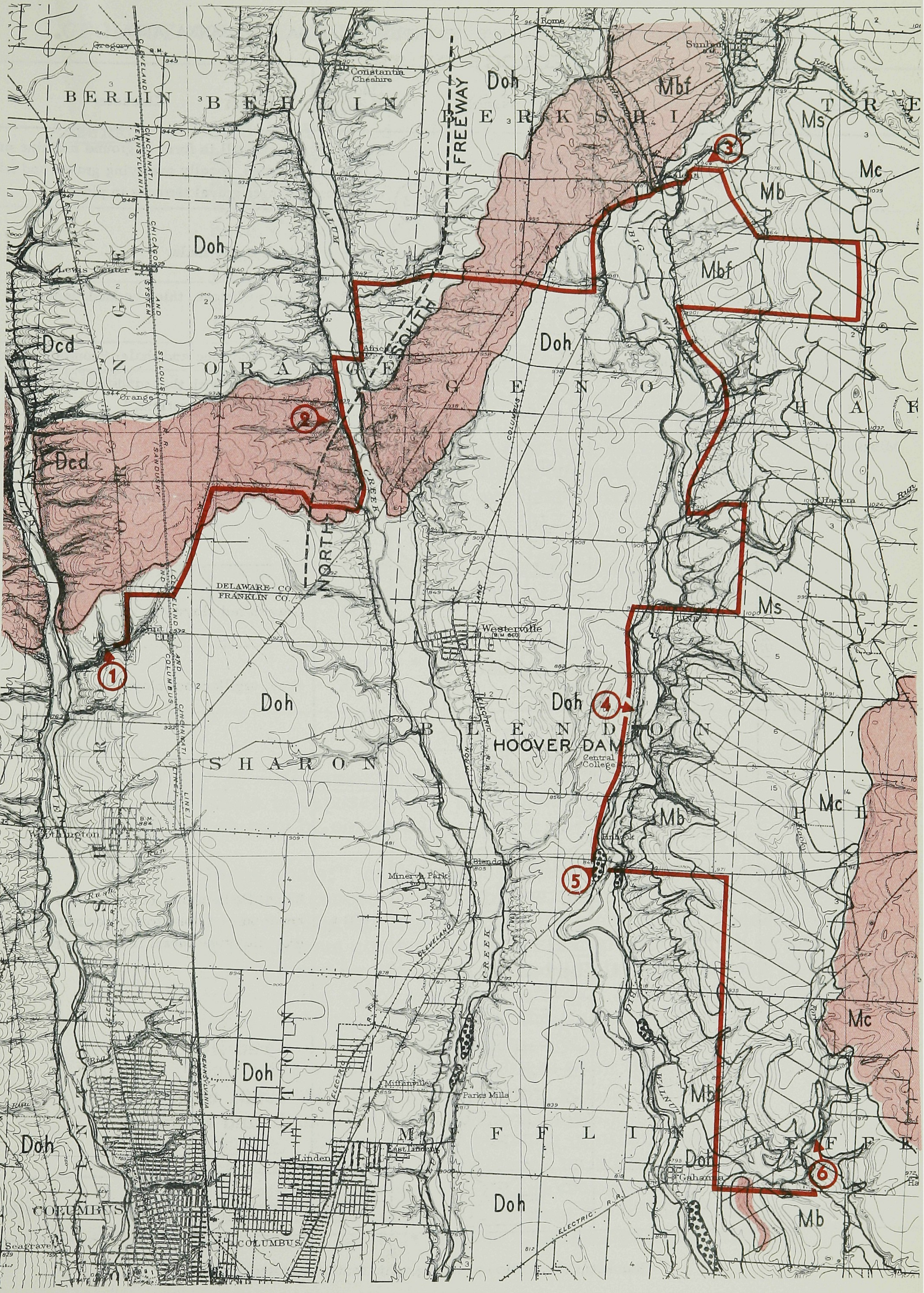
## GEOLOGY OF THE
## COLUMBUS - GALENA - GAHANNA AREA

| Period | Symbol | Unit |
|---|---|---|
| Quaternary | | Esker |
| Quaternary | (Red) | End moraine |
| Mississippian | Mc | Cuyahoga formation |
| Mississippian | Ms | Sunbury shale |
| Mississippian | Mb | Berea sandstone |
| Mississippian | Mbf | Bedford shale |
| Devonian | Doh | Ohio shale |
| Devonian | Dcd | Columbus-Delaware limestone |

Field trip route shown by heavy red line.

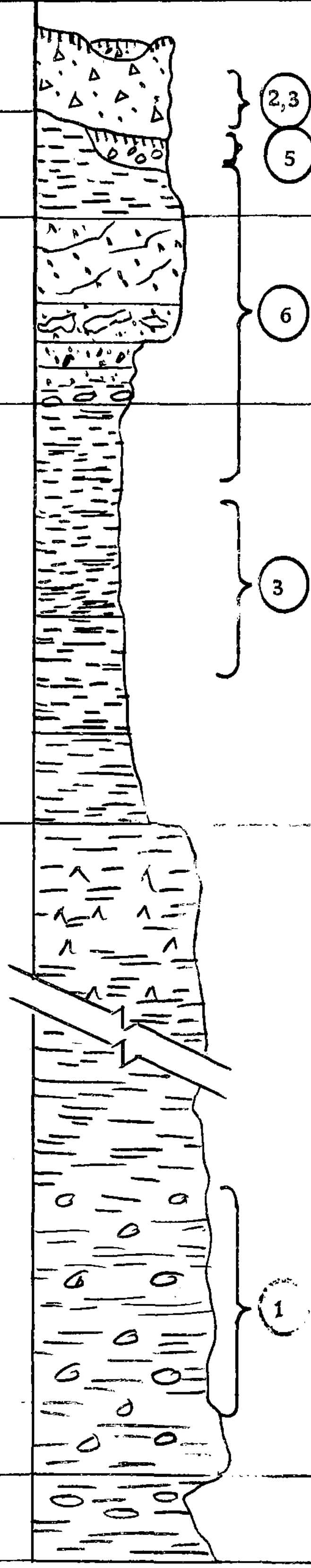
Glacial geology from R. P. Goldthwait, 1958, unpublished.
Bedrock contacts from Stauffer, Hubbard, and Bownocker, 1911.



BERLIN
BERKSHIRE
FREEWAY
NORTH
SOUTH
ORANGE
GENOA
SHARON
BLENDON
HOOVER DAM
MIFFLIN
Doh
Mbf
Ms
Mc
Mb
Dcd
DELAWARE CO.
FRANKLIN CO.
Westerville
Central College
Constantia
Cheshire
Lewis Center
Orange
Worthington
Minerva Park
Blendon
Parks Mills
Linden
East Linden
Gahanna
Columbus
COLUMBUS
Seagrave
Rome
Sunbury
Hartford
ALUM CREEK
BIG WALNUT
1
2
3
4
5
6

STRATIGRAPHIC SECTION FOR THE COLUMBUS - GALENA - GAHANNA AREA

| System | Formation | Section | Thickness in Feet | Character |
|---|---|---|---|---|
| Quaternary | | | Till 25 ± 150 ± in moraines | Glacial till in form of ground moraine and end moraine, locally overlying gravel and with younger gravel terraces in places. |
| Mississippian | Sunbury shale | | 36 | Black fissile shale. |
| | Berea sandstone | | 18 | Gray sandstone, thick bedded, lenticular |
| | | | 8 | Gray sandstone and shale; "contorted" layers. |
| | | | 13 | Gray shale with thin sandstone layers; basal sandstone "concretions." |
| | Bedford shale | | 47 | Gray argillaceous claystone. |
| | | | 26 | Grayish red claystone. |
| | | | 18 | Gray, argillaceous claystone. |
| ? | | | | |
| Devonian | Ohio shale | | 400 ± | Black, fissile shale; cone-in-cone layers in upper part; "iron-stone" concretions and gray claystone layers in lower part. |
| | Olentangy shale | | 28 | Gray claystone with lenticular concretions. |




Brackets show portion of stratigraphic section exposed at stops.

# GEOLOGY OF THE COLUMBUS - GALENA - GAHANNA AREA

* * * * * * * * * * *

Assembly - 8:00 A. M. in roadside park on route U. S. 23, 2.6 miles north of Worthington. Leave cars parked in roadside park area and walk west along road to Mary Orton camp to where that road bends sharply right (north); leave the road here where marked and go diagonally left (southwest) along small ridge to exposure in ravine. Return to cars by same route. Extra guidebooks and topographic maps will be available when the group returns to the cars. Departure from this stop is planned for 9:15 A. M.

Drivers - A large number of cars are expected, so please place your car in assembly area so that the largest possible number of cars can be accomodated. Markers for your cars will be provided before leaving this stop. As we continue on the trip, please stay in line and drive carefully; some of the roads we will encounter are heavily travelled main highways.

Because of the large number of people expected on this trip, all persons are urged to stay with the group and to move to and from cars at stops promptly.

* * * * * * * * * * *

| Mileage | | |
|---|---|---|
| Individual | Total | Road Log |
| 0.0 | 0.0 | STOP 1 - Glenmary (Flint) Ravine. The lower portion of the Ohio shale is exposed along the stream where the following features may be observed: |

1. "Black shale;" carbonaceous, fissile, with zones containing dolomitic concretions and pyrite, characteristically well-jointed. The age and origin of the black shale represent one of the famous controversies in stratigraphy, which is well summarized by Mr. Karl Hoover in his forth-coming publication of the Ohio Geological Survey. L. C. Conant is heading a comprehensive study of the Chattanooga shale for the U. S. G. S. and, with Dunbar, "we may hope for a more definitive solution of the problem when the current project... is completed."

2. Fossils. Because of the scarcity of other fossils, conodonts are of stratigraphic importance, as Wilbert Haas has demonstrated in his recent U. S. G. S. Professional Paper 286 (1956). In this publication he uses the sequence of conodont fossil zones to correlate the Chattanooga shale with the

Ohio shale, which he believes to be entirely of Devonian age. Other fossils include a number of plants, carbonized and silicified, plant spores in local abundance, and plates and skeletal material of fish.

3. Concretions. The so-called "iron-stone" concretions are as characteristic of the lower portion of the Ohio shale as they are of the Huron shale of northern Ohio. They are chiefly composed of dolomite (65%), with subordinate amounts of calcite (15%), and even less siderite (5%), but the weathering of the siderite forms the limonitic surface, hence the term "iron-stone." They range in diameter generally from 1 to 6 feet. Their origin has most recently been explained as penecontemporaneous by H. Edward Clifton in the Ohio Journal of Science (1957), growth having taken place after deposition of the sediments but before consolidation. Fossils served as nuclei; the well preserved fish remains found in some of the concretions have made them famous.

4. Jointing. A well-developed joint system may be observed here in the Ohio shale, which consists of two prominent sets trending generally northwest and northeast. They intersect approximately at right angles and are nearly vertical. Minor sets also occur. The jointing has been subject of a number of theses, but no thorough formal treatment has been published.

5. Stream piracy. Piracy produced by lateral erosion of the main stream has beheaded a small tributary, thus producing a miniature of the classic Couler Valley (Lancaster, Wisconsin, topographic map). The diverted tributary is still out of accord with the main stream and joins the main stream in a small falls at the point of juncture (a hanging valley).

6. Vance well. A deep well was drilled one and a half miles due north of Glenmary Ravine in the years 1934-1937. It penetrated the rock section from the Olentangy shale down into the basement complex at a total depth of 3,892 feet below the surface. Samples from this drilling operation were analyzed and reported on by Stout and Lamey (1940, in A. A. P. G. Bulletin). The section given below is taken mostly from their publication. Mr. George Shearrow (Ohio Geological Survey, Oil and Gas Section) has recently rerun samples from the Black River and older units; his newer determinations replace those of Stout and Lamey in the lower part of the list below.

## Section of Vance Well

| System | Formation or Group | Depth to Top of Unit | |
|---|---|---|---|
| Devonian | Ohio | 0 | |
| | Olentangy | 126 | |
| | Delaware | 150 | |
| | Columbus | 188 | |
| Silurian | Monroe | 280 | |
| | Niagara | 690 | |
| | Alger | 830 | |
| | Dayton | 880 | Data from Stout and Lamey, 1940. |
| | Brassfield | 940 | |
| | Elkhorn | 1,005 | |
| Ordovician | Richmond & Maysville | 1,060 | |
| | Eden | 1,650 | |
| | Utica | 1,930 | |
| | Trenton | 2,100 | |
| | Black River (upper) | 2,250 | |
| | Glenwood | 2,653 | |
| Cambrian | Trempealeau | 2,705 | Data from George Shearrow, unpublished. |
| | Franconia | 3,170 | |
| | Eau Claire | 3,290 | |
| | Mount Simon | 3,705 | |
| Pre-Cambrian | Basement Complex | 3,840 | |
| | | 3,892 T. D. | |

Leave Stop 1 by turning left onto U. S. 23 <u>with care.</u> Note outcrop of weathered Ohio shale almost immediately on right (east), as highway climbs bluff of Glenmary Ravine.

0.3 0.3 This is ground moraine of Wisconsin age. The Powell end moraine may be seen ahead where the road rises up onto it. The Wisconsin end moraines of Ohio appear to occur in groups. The most northern group begins with, or is delineated on the south by the Powell moraine, which has been interpreted as representing the outer edge of Cary drift in Ohio.

0.3 0.6 Note unusually large number of good-sized boulders in field to right (east). No boulder belt, such as is present elsewhere in Ohio is known here; it is likely that these boulders simply mark a concentration produced by the readvance of the ice which deposited the Powell moraine.

0.2 0.8 Turn right (east) off U. S. 23 at county boundary onto Lazelle Road. At this point we are actually on the foot of the Powell moraine, but, after passing through the small valley here, the road rises up only onto ground moraine (see map); the Powell moraine may be observed to the left about half a mile away from 0.4 miles ahead.

0.6 1.4 Pass through underpass beneath New York Central Railroad and immediately turn left (north) onto Delaware County road 10.

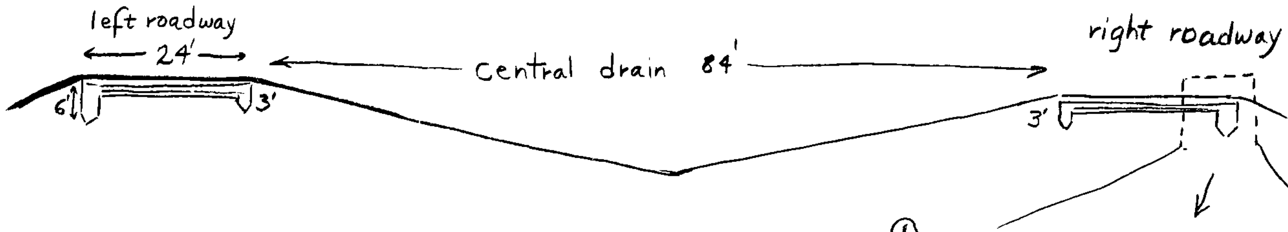
0.5 1.9 This is Wisconsin ground moraine. The Powell moraine may be seen ahead to the left and directly ahead where the road rises up onto it. As road ascends moraine, note change in steepness of slopes and increase in hummockyness.

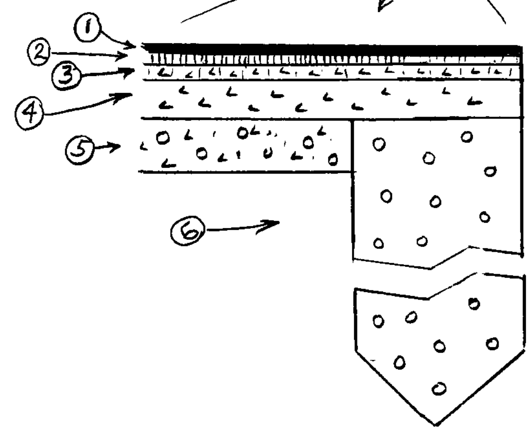
1.1 3.0 Turn right (east) onto Delaware County road 14. We are near the crest of the Powell moraine, which lies a quarter of a mile to the west and half a mile to the north from this intersection. The thickness of the drift just east of us is greater than 110 feet, but on the ground moraine from where we have just come it is shallow (21 feet in one well). A mile north of this intersection, on the north edge of the moraine, a well record gives 34 feet to bedrock (Ohio shale). (Drift thicknesses courtesy of Mr. James Schmidt, Division of Water.)

0.8 3.8 Note view to right (south) of ground moraine at foot of Powell moraine. House a quarter of a mile away is barely on the edge of the moraine. Note contrast in topography between the end moraine in the foreground and the ground moraine in the distance.

0.5 4.3 Route crosses construction for new North-South Freeway. Exposures here are good, but the till is covered by a poorly-sorted silty material so that the soil profiles are somewhat complicated. Soils men have found such silty veneers characteristically occurring on the lower fore-slopes and in front of end moraines many places in Ohio. This apparently represents material washed from the surface of the end moraine in the time since the moraine was deposited, a process which seems to have been contemporaneous with soil formation in both areas (the area that lost the silty material and the area where it was deposited).

In a chat with the project engineer for this part of the Freeway, the occurrence of some buried silt half a mile north of this overpass was reported. The silt, which was 10 to 15 feet thick, was not encountered until excavation had almost reached proposed road level. Silt is bad material for road beds for two reasons: (1) it has no real strength and (2) it tends to hold moisture, which can then freeze and break up the enclosing road material. The first of these effects is the most serious in this climate and has made necessary the unpredicted expenditure of considerable extra funds in order to prepare adequate support in this area for the amount and weight of traffic expected on the North-South Freeway. The problem of holding water, which is of less importance in this state anyway, is solved by the nature of the road bed construction, which will be according to the highest state specifications. The general cross profile of the four-lane highway will be:




The actual detailed structure of part of one of the roadways is shown here in cross section, with the numbered units described below:

1. Black top (asphalt) : $1\frac{1}{4}$ "
2. Coarser grained black top (asphalt) : $2\frac{3}{4}$ "
3. Bituminous macadem (angular stone $\frac{1}{4}$ to 1 inch in diameter in a bituminous matrix) : 3"
4. Angular stone 1 to 2 inches in diameter: 8"
5. Gravel-loam mix (with pebbles less than 3 inches in diameter) : 9"
6. Gravel drains along margins of each roadway: 6 feet deep on outer margins and 3 feet deep on inner edges.

0.6 4.9 View ahead (east) to Alum Creek valley. We are well down on the outer edge of the Powell moraine, which here swings more toward the north. The difference between the higher land of the moraine to the left and the lower land of the ground moraine south of it, to the right, may be seen from this spot. Alum Creek has cut its valley through the moraine, with the result that the valley is locally more narrow.

0.2 5.1 Turn sharp left (north) onto Orange Township road 107. This road follows the valley of Alum Creek where it has cut through the Powell moraine. Watch for the change in width of the valley bottom.

0.7 5.8 We are now about on line with the Powell moraine. Note the hummocky topography to the left and the narrowness of the valley to the right.

0.2 6.0 Here the valley broadens, but morainic topography can still be seen on both sides of the valley. On the floor of the valley, adjacent to the road, are a series of alluvial fans, associated with small creeks, flowing from the moraine east into the valley. Alum Creek valley is deep here, with steep sides (see map), so that the development of alluvial fans is quite expectable. An interesting problem relating to these fans is their composition: are they composed of gravel, alluvium, colluvium, or till? Half a mile ahead, an exposure in one of these fans, not far from the valley wall, shows five feet of poorly sorted alluvial silt and gravel over till. Whether their composition might change farther out in the valley and whether the smaller fans, formed by the mouths of smaller creeklets might be different is not known. A careful study of these fans might be an interesting problem.

0.4 6.4 Cross Freeway right-of-way and park along road as far to right as possible.

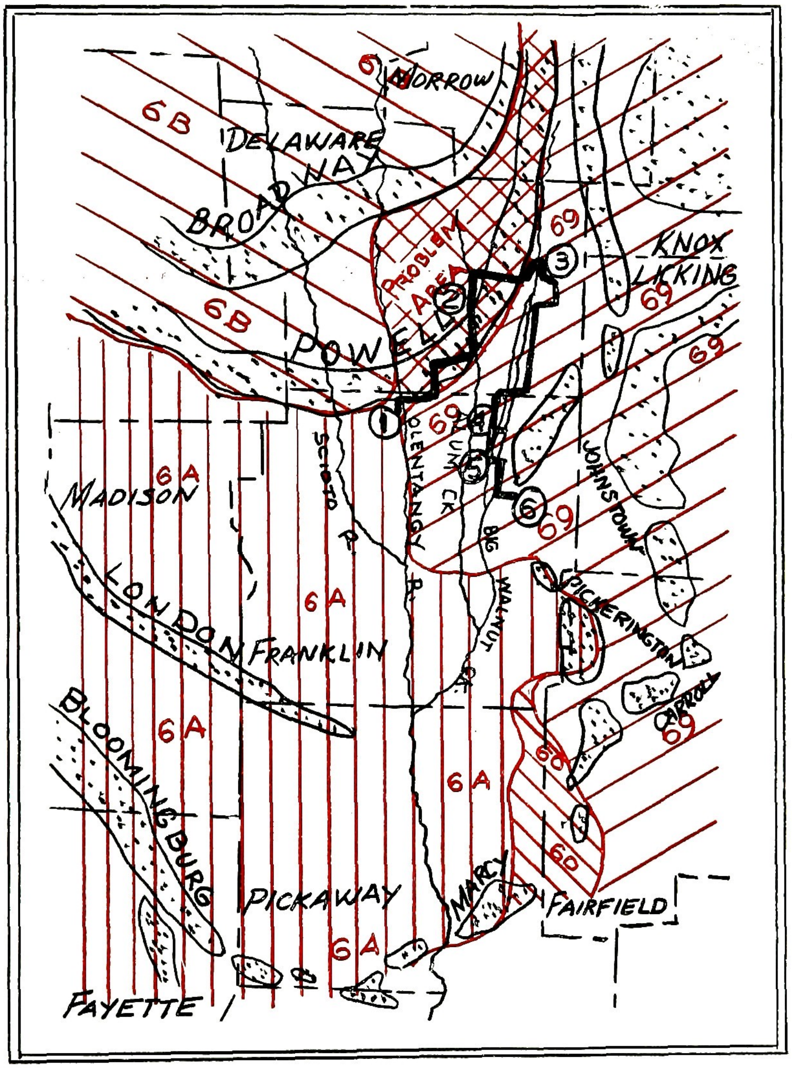
<u>STOP 2</u> - <u>Soil profile in Powell moraine area.</u> Soils mappers have identified four kinds of soils developed in till in central Ohio (see small map). Actually, each of these kinds of soils is a whole catena, or group of soils formed in the same parent material, but under different topographic and drainage conditions. Because, as geologists, our main interest is in parent material, we will consider only the catenas as a whole.

The four soils (or catenas of soil) are: to the northwest, the Morley soils (mapping symbol 6B); to the west, the Miami heavy subsoil or Miami variant soils (mapping symbol 6A); to the southwest, the Miami (as now restricted) soils (mapping symbol 60); and, to the east, the Alexandria soils (mapping symbol 69). These soils differ from one another in the percentage of clay in the B horizon (or subsoil), the percentage of clay in the parent material (till), the lime carbonate content of the parent material, the depth of leaching, and other, less easily recognized characteristics. The values of these four variables for each of the four kinds of soils are shown in the chart below. The figures given in the chart are not extremes, but a suggestion of the expectable general range in the values.

| | Miami (60) | Miami Variant (6A) | Morley (6B) | Alexandria (69) |
|---|---|---|---|---|
| Clay in B horizon | Mod. 33-38% | *High 40-50% | * High 45-55% | Mod. 33-43% |
| Clay in Till | Low 15-27% | Low 15-27% | * Mod. 28-38% | Low 15-27% |
| Carbonates in Till | High 30-45 % | High 30-45% | Mod. 25-30% | *Low 12-17% |
| Depth of Leaching | *Mod. 24-36 " | Shallow 16-25 " | Varied 17-32 " | Deep 32-48 " |

* Significant characteristic.

The Alexandria (69) soils are different from all the others because of their low percentage of carbonates, which is presumed to reflect the change in composition of the underlying bedrock. The percentage of sand is also often higher. The reason for these differences, as shown on the small map, is that these soils lie toward the east, their western boundary being generally coincident with the western limit of Mississippian sandstone and shale.




End moraine

Route of field trip

Soil Catenas

6B - Morley
6A - Miami Variant
60 - Miami (restricted)
69 - Alexandria

Map showing distribution of major soil catenas in central Ohio.

The other three soils, which in the past were all mapped Miami, have reasonably high contents of lime. Their critical differences lie in the percentages of clay in the B horizon and in the parent till. The Miami as now restricted (60) is not high in clay in either the B horizon or the parent material; it also appears to be weathered stronger and more deeply than the other high-lime soils. Since it forms a more southern belt in the area of high-lime Wisconsin till in Ohio, an actual difference in the time since the deposition of the till has been suggested as the critical factor.

The Miami variant (6A) is high in clay only in the B horizon (subsoil); the increase in clay content from the parent material to the B horizon is very striking. Most of the clay found in any B horizon forms from the parent material; why the increase should be so much greater in the case of the Miami variant (6A) than it is in any of the other central Ohio soils is not clear.

The Morley (6B) soils are characterized by high percentages of clay in both the parent material and the B horizon; the difference between these two clay content values is not as striking as it was in the case of the Miami variant (6A). The best explanation for the higher clay content in this till is that temporary lakes were formed during the glacial retreat that preceded the advance associated with this till and that clays deposited in these lakes were picked up by the ice in its subsequent readvance and were incorporated in the till.

The local distribution of these four kinds of soils is shown on the accompanying small map. Beyond the limits of this map, the southern limits of the three more western, high-lime soils may be traced westward to or almost to the Indiana line: the Morley (6B) soils along the Powell-Union City moraines, the Miami variant (6A) soils along the Reesville-Farmersville moraines, and the Miami (60) (and associated silt-capped Russell soils) along the outer boundary of the Wisconsin drift area. Thus it may be seen that these three soils occur in east-west belts across Ohio, suggesting that they have chronological significance in the story of Ohio's Pleistocene history. The Miami (60) soils are apparently developed in a somewhat older till (still late Wisconsin) and the Morley (6B) soils are formed in clay-rich till associated with a glacial readvance following a retreat which allowed the formation of ice-marginal lakes in which clay deposits accumulated.

The Alexandria soils are different. They are low in lime content and relatively high in sand and so simply reflect the composition of the Mississippian bedrock. Thus, this soils change has no real significance in the Pleistocene story. The time intervals represented by the lines separating the Miami (60), Miami variant (6A), and the Morley (6B) soils presumably extend eastward to <u>within</u> the area of Alexandria soils, but they have not yet been identified there.

One small area remains to be dealt with. This area lies in Delaware County south of the Broadway moraine, north of the southern edge of the Powell moraine and east of the Olentangy

River. In this area carbonate percentages are a little too high for typical Alexandria soils, but are not really high enough for good Morley or Miami variant soils. Furthermore, the clay contents are far below those characteristic of either the Morley (6B) or Miami variant (6A) soils.

Much of the data for this discussion of the soils of central Ohio has been taken from a thesis by Kenneth Wenner, who completed his Master's degree at Ohio State University this last March in Agronomy under Dr. Holowaychuk. It is he who identified this area and the nature of its problem. Wenner's conclusion was that the area needs more study to determine whether the ranges of characteristics of the pre-existing soils should be extended to include the intermediate-nature soils found here or whether there should be a new soil established. Whatever this problem soil is called, it is the soil exposed at Stop 2, because an analysis of this till (courtesy of the Ohio State University Agronomy Laboratory) shows the following values:

| | | | |
|---|---|---|---|
| Carbonates: | 16.7 | Clay content: | 26.4 |
| | | Silt content: | 49.9 |
| | | Sand content: | 23.7 |

A pebble count here (tabulated composition of 100 pebbles 1 to 3 inches in diameter) shows:

| | | | |
|---|---|---|---|
| Dolomite | 33 | Total carbonates | 51 |
| Limestone | 12 | | |
| Chert | 6 | | |
| Black shale | 43 | Total clastic | 43 |
| Granite | 4 | Total crystalline | 6 |
| Gneiss | 1 | | |
| Quartzite (pink) | 1 | | |
| | | | 100 |

(Compare these figures with those given for the till at Stop 3.)

Departure from this stop is planned for 10:30 A.M. Continue on northward along Alum Creek valley.

0.1 6.5 Note cut in Ohio shale across river along Freeway right-of-way.

0.5 7.0 Note exposure of Ohio shale back to left on south side of small creek.

| | | |
|---|---|---|
| 0.3 | 7.3 | Turn right (east) onto Orange Township road 109. Note that approaches to bridge over Alum Creek have had to be repaired; at the heighth of the flood, the water here was all the way up to the level of the bridge, flooding the valley and the bridge approaches on either side. |
| 0.4 | 7.7 | Town of Africa. Turn left (north) onto Delaware County road 21. This road lies above bluff of Alum Creek, but the land is not high; it is ground moraine which has been somewhat dissected due to its proximity to the river. The Powell moraine lies south and east of us. |
| 0.8 | 8.5 | Note exposure of Ohio shale back to the right on south side of small creek, across small valley from Africa cemetary. |
| 0.3 | 8.8 | Turn right (east) onto Delaware County road 106. We will follow this road eastward for 3.6 miles. |
| | | Excavations ahead to left in valley are large gravel pits in glacial outwash. The materials are unusually coarse (cobbles up to a foot in diameter are abundant) and contain a remarkably high percentage of Ohio shale pieces. The gravel shows good horizontal bedding and is more than 30 feet thick. |
| 0.3 | 9.1 | Note land surface to right and left; this is ground moraine which has been locally somewhat dissected. The Powell moraine lies less than half a mile ahead (see map). |
| 0.3 | 9.4 | Note exposures of till in road cut to left and in twenty-foot bank to right across small creek. |
| 0.2 | 9.6 | Ohio shale is exposed along the bottom of the creek to the right and, very much weathered, in the road bank ahead, as road ascends stream bluff to level of ground moraine. |
| 0.3 | 9.9 | Turn left onto short detour, where road crosses Freeway right-of-way. Note that excavation in connection with road building here has encountered shale bedrock, which may be observed in dump to left. Good soil profiles are present in the cuts along this new road. We are approaching the backslope of the Powell moraine here, which can be seen poorly ahead; by the time we have left the little detour we are <u>on</u> the moraine. |
| 1.1 | 11.0 | Crest of Powell moraine. Note hummockyness of moraine and relatively steep slope off to the ground moraine toward the southeast. Drift on the end moraine here is more than 158 feet thick, while it averages only about 30 feet thick on the ground moraine to the southeast (sample well records |

show 11, 26, and 56 feet to bedrock). (Well record data courtesy of Mr. James Schmidt, Division of Water.)

The Berea sandstone escarpment may be seen in the distance to the east.

0.5 11.5 Stop sign. Continue straight on (east) across Ohio Route 3 with care and across rather bumpy railroad tracks. Note boulders in valley to left (north) just beyond railroad tracks, again at the outer foot of the Powell moraine.

0.4 11.9 Good view of relatively flat ground moraine. Berea escarpment may again be observed, though not too clearly, in the distance ahead (east). Hoover Reservoir, though not visible from here, lies between.

0.3 12.2 Stop sign. Turn left (north) onto Delaware County road 106, which is a new road (not shown on Westerville quadrangle).

0.1 12.3 Hoover Reservoir to right and, back to right, forming south bluff of drowned valley, is cut exposing over 35 feet of Ohio shale. Road immediately rises back up onto flat ground moraine surface, from where there is a good view of Galena ahead to the northeast, Hoover Reservoir to the east (right), and the Berea sandstone escarpment far to the east.

1.5 13.8 Cross drowned Little Walnut Creek valley at northern end of Hoover Reservoir and enter town of Galena. Continue straight (east) through town (road bends slightly to right).

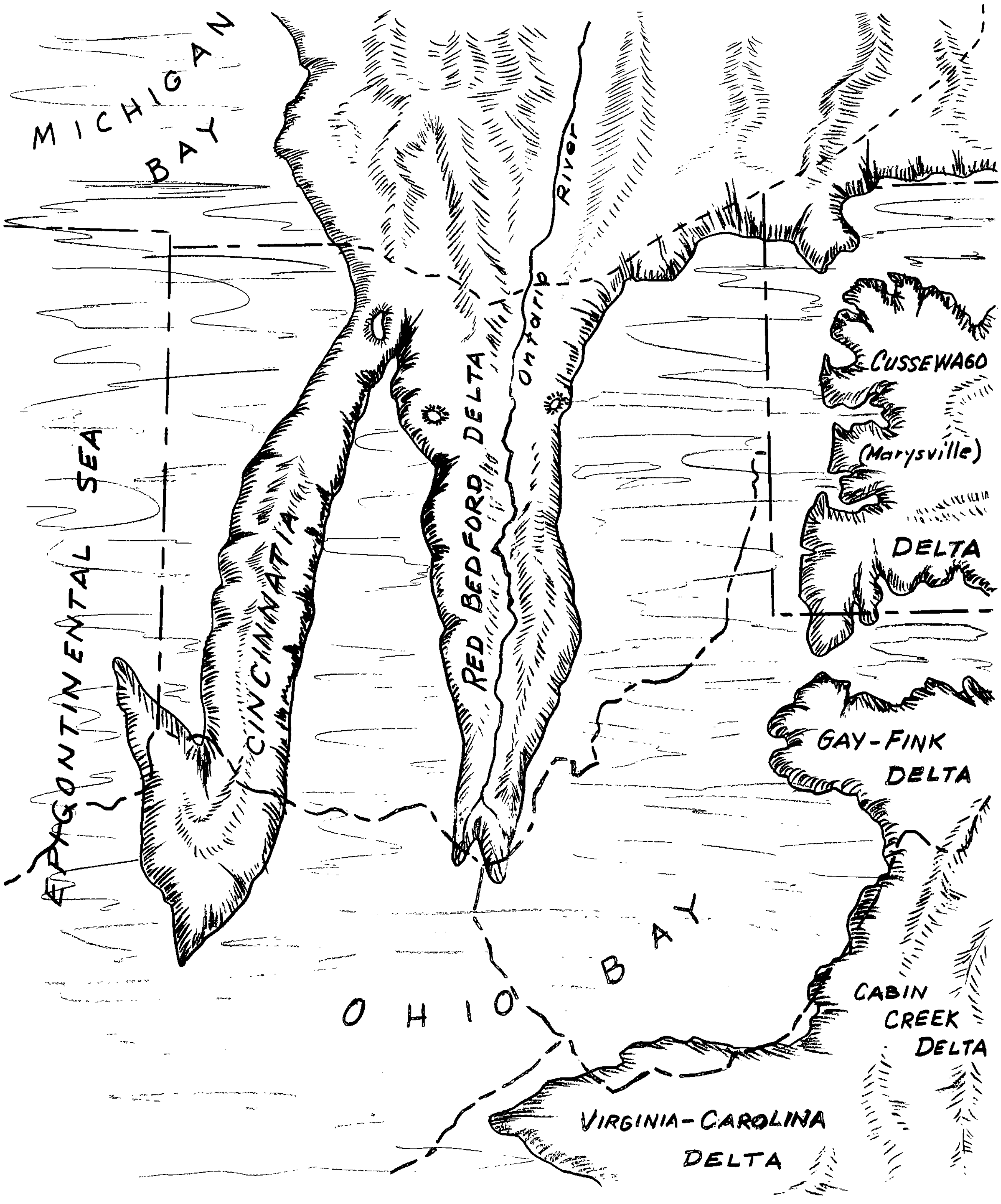
0.3 14.1 Stop sign in Galena. Continue straight ahead (east) across valley of Big Walnut Creek on Delaware County road 30. View to right along road shows, though not too clearly, where that road was washed out by this year's floods. Cuts along Big Walnut Creek in the same direction expose poorly sorted "gravel" composed almost completely of deteriorating shale chunks and competent sandstone slabs, which show shingling.

0.2 14.3 Turn left (northeast) onto Delaware County road 19, on the east side of the Big Walnut Creek floodplain, and ascend valley bluff toward northeast.

0.3 14.6 Follow Delaware County road 19 to diagonal right (east).

0.4 15.0 STOP 3 - The Galena Shale Tile and Brick Company Pit,

Bedford shale. - Gray, soft claystone, 15 feet of which is exposed, overlying "red" claystone about 3 feet thick, which in turn is underlain by 15 feet of gray claystone with interbedded thin, gray, silty mudstones. Thus, this pit exposes




Paleogeographic map of Bedford time. (From Pepper, et al., 1954, pl. 13C.)

about a third of the total thickness of the formation, which is about 100 feet.

The middle unit, or "red shale," thickens northward at the expense of the gray shale so that, in northern Ohio, the formation is predominantly reddish. The basal contact with the Ohio shale is transitional. The Bedford is non-fossiliferous except for a basal zone 1 or 2 feet thick which contains a few brachiopods and mollusks. This is a critical faunal zone, however, and its age determination would have an important bearing on locating the Devonian-Mississippian contact. Stratigraphically above this section the gray Bedford claystone contains interbedded, gray, hard siltstones, which increase in number upward, grading into the overlying Berea sandstone in central and southern Ohio. From central Ohio northward the upper contact of the Bedford is disconformable with a relief of from 5 feet to near 50 feet. This disconformity accounts for the wide variation in thickness of the Bedford and Berea formations.

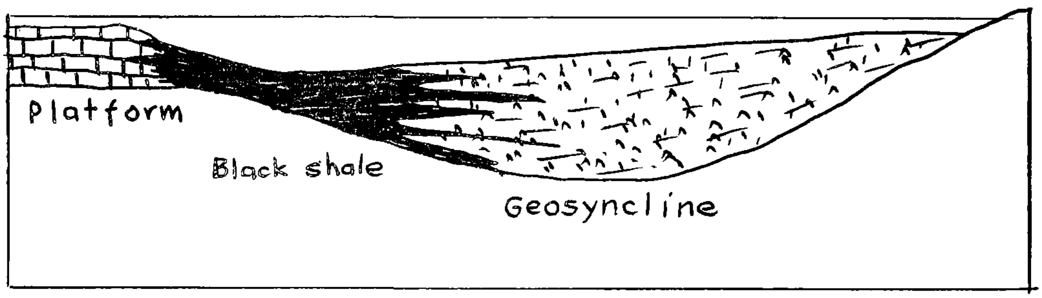
Berea Sandstone. - The Berea sandstone forms the low escarpment about one mile east of this location. It is a medium- to fine-grained, clay-bonded quartz sandstone. Here it is about 65 feet thick, but in Lorain County in northern Ohio it reaches its maximum thickness of 235 feet. In places it is only 1 foot thick. In south central and southern Ohio, the Berea contains interbedded siltstones and is not distinguishable from the upper part of the Bedford.

Sunbury Shale. - Conformably overlying the Berea sandstone is the Sunbury shale, which is about 25 feet thick. It is black, carbonaceous, and fissile, resembling the Ohio shale. A thin bed of pyrite marks the basal contact in many places and there is a basal zone a few inches thick containing conodonts and the brachiopods Lingula and Orbiculoidea. The Sunbury grades upward into the Orangeville shale, the basal unit of the Cuyahoga.

Red Bedford Delta. - The complex mass of stratigraphic detail presented by the Ohio-Bedford-Berea-Sunbury section has been synthesized by Pepper, DeWitt, and Demorest in their recent U. S. G. S. Professional Paper 259 (1954) entitled "Geology of the Bedford Shale, and Berea Sandstone in the Appalachian Basin," in which the concept of the now famous Red Bedford Delta was developed on the basis of an extremely detailed study of many outcrops and 43,000 well records.

On the basis of their lithologic studies, Pepper and his colleagues place the Devonian-Mississippian systemic boundary at the Ohio-Bedford contact, thus agreeing with a host of previous geologists through the past 60 years, starting with Edward Orton in the 1890's and continuing through to such recent workers as Haas, Nelson, and others in the 1950's.

Following the deposition of some limy precipitates followed by limy muds, which were laid down in the western portion of the Appalachian geosyncline and now make up the Columbus-Delaware-Olentangy formations, the peculiar conditions necessary for the accumulation of thick, widespread layers of black mud developed in late Devonian time. Such conditions, as proposed by Dunbar and Rogers in "Principles of Stratigraphy," (1958, p. 206) require that the rate of supply of organic matter be greater than its rate of destruction. How this ratio is attained has been a source of controversy for many years; it could have occurred on a marginal shelf lying between a stable platform and the geosyncline, as shown on the accompanying diagram (from Dunbar and Rogers). With the filling of the geosyncline by clastic materials from the east, the fine muds and organic matter would have been deposited farther westward where quiet water still existed in the trough.



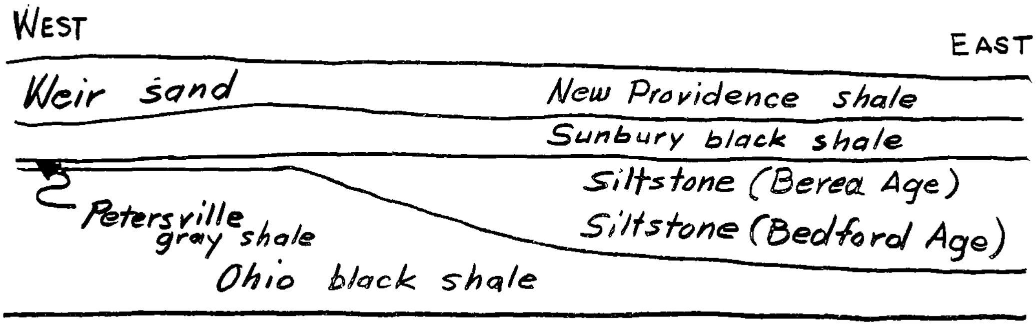

Hypothetical section across a geosyncline bordered on the left by a stable platform and on the right by highlands. (After Dunbar and Rogers, 1958, p. 206)

After deposition of the black mud, that portion of the Appalachian geosyncline known as the Ohio Bay became restricted by marginal deltaic deposits along its eastern margin, which lay in western Pennsylvania and eastern West Virginia; it was bordered on the west by Cincinnatia. (See accompanying paleogeographical sketch map for the beginning of Bedford time.) The most striking feature of Bedford time in this area (also shown on paleogeographic map) was the extensive development of a delta southward through the middle of the Ohio Bay, 210 miles long and 50 miles wide. It has been named the Red Bedford Delta, and was formed by a large river, known as the Ontario River, flowing southward from the Canadian Shield, which transported large quantities of red soil materials. The pattern of delta construction bears close resemblance to the present Mississippi delta.

As the Red Bedford Delta grew, the outer marine sediments, bleached gray by deposition in a reducing environment, were progressively buried by the subaerial deposits, which retained their red color because of because of being deposited under oxidizing conditions. Subsidence followed the maximum development of the Delta, so that gray muds and silts were deposited on top of the red layers. These consolidated gray beds, with the red shale zone between, now form the Bedford shale of central Ohio. In northern Ohio, where subaerial deposition predominated, the entire formation is red.

As time continued, increasingly clastic materials were carried over the delta surface and into the adjacent shallow sea. In central and northern Ohio these were deposited as channel sands. The shallow marine and channel sands compose the Berea sandstone.

Continued subsidence caused an expansion of the Ohio Bay northward again and a return to conditions favoring the deposition of black mud. These consolidated sediments make up the Sunbury shale. Southward and westward in the Ohio Bay beyond the delta, black mud deposition was nearly continuous and, in Kentucky, the Ohio and Sunbury shales are separated by only a thin layer of gray shale, the Petersville shale. The following sketch, modified from Pepper, et al., p. 38, shows these relationships in Kentucky.




Generalized section showing shales and siltstones in eastern Kentucky (after Pepper, et al., 1954, p. 38).

Glacial Till and Soil Profile. - This stop lies on the ground moraine outside of the Powell moraine, but inside (west) of the Johnstown moraine, whose edge may be seen in the southeast corner of the accompanying map. The glacial till here in the quarry varies from less than 10 feet to more than 25 feet thick. It is lower in carbonate content than the till seen at Stop 2 and higher in sandstone pebbles. The soil profile belongs to the Alexandria catena. Note the low carbonate content in the laboratory analysis below (courtesy of the Ohio State Agronomy Department Laboratory):

| | | | |
|---|---|---|---|
| Carbonate content: | 4.4% | Clay content: | 23.6% |
| | | Silt content: | 46.9% |
| | | Sand content: | 30.5% |

Results of a pebble count show the following composition of pebbles 1 to 3 inches in diameter:

| | | | |
|---|---|---|---|
| Dolomite | 8 | Total carbonates | 19 |
| Limestone | 6 | | |
| Chert | 5 | | |
| Black shale | 21 | Total clastic | 75 |
| Gray shale | 3 | (total sandstone 51!) | |
| Ferruginous sandstone | 19 | | |
| Gray sandstone | 32 | | |
| Granite | 2 | Total crystalline | 6 |
| Quartzite (white) | 3 | | |
| Diorite | 1 | | |
| | | | 100 |

Economic Geology. - (this information has been obtained by Mr. Karl Hoover, of the Ohio Geological Survey.) The Bedford shale is quarried for the clay from which is made brick, tile, and various other products. In processing the shale, they like to have a good mixture of the red and the gray shale units, as the red shale has somewhat different shrinkage properties. Thus, they are encountering a problem in this pit, where the red unit is so thin. They have considered using the till, also, in their manufacture, but the carbonate content, despite being so low, is too high for such production and causes bloating in their face brick.

Another interesting problem connected with the quarrying operation is that, in order to continue their private railroad line, by which the quarried material is moved from the quarry to the plant, they must work down-dip; thus they always have the problem of standing water with which to contend.

Departure from this stop is planned by 12:00.

Continue on by turning right (southeast) onto Delaware County road 22, just before crossing small bridge. Road lies on till-covered Bedford shale surface; Berea escarpment may be observed to left (east), about half a mile away.

0.4 15.4 Note boulders on left along fence row just this side of barn and along both sides of the road farther along. It has been observed by Lois Campbell in northern Ohio that boulders are often relatively common in areas where the bedrock is shallow. Here, it is not clear whether boulders occur because of the shallowness of the bedrock or because of a locally more extensive push forward of the Powell ice (making the origin of these boulders similar to that of the boulders observed earlier along the foot of the moraine), but the former suggestion seems more likely here.

0.8 16.2 Road swings left (due east) toward the Berea escarpment.

0.3 16.5 Berea sandstone may be observed exposed in the ditch along the left (north) side of the road opposite the first house.

0.1 16.6 A small water-filled quarry in Berea sandstone may be observed on the left side of the road shortly before the flat Berea surface is reached.

1.0 17.6 Stop sign. Turn right (south) onto Delaware County road 18, which follows the flat Berea surface. Bedrock lies at a depth of only about 25 to 35 feet in this area.

1.2 18.8 Turn right (west) at abandoned school onto Delaware County road 23. The low smooth hills visible to the east and south of this intersection (see map) are apparently bedrock-controlled. Drift is about 25 feet thick on and around them (Courtesy of Mr. James Schmidt, Division of Water).

1.0 19.8 Begin descent off Berea escarpment.

0.4 20.2 Note Berea sandstone "float" in ditch to right. Bedford shale is exposed to the right and the left in the creek bottom 0.2 miles ahead, so the contact must be near here.

1.1 21.3 Turn left (south) onto Delaware County road 30, along east side of Hoover Reservoir. We will follow this road for 5.4 miles.

0.9 22.2 Descend into steep little valley of unnamed tributary of Big Walnut Creek. Cuts along the road at the tops of both bluffs expose till with what is probably Alexandria catena soils developed in it. The red shale unit of the Bedford is exposed near the bottom of this valley in a number of places; the roadcut in the peninsula of land between the two streams shows both the red shale and the overlying blue shale Bedford units.

| | | |
|---|---|---|
| 0.7 | 22.9 | Red Bedford shale is exposed along the far side of the creek to the left (east) of the road. |
| 0.1 | 23.0 | An interesting glacial boulder is present on the right side of the road, opposite the side road on the left and to the far (left) side of a gate in the fence. It is a dark gray granitic rock with a large red "cross" of pink pegmatite (of quartz and pink feldspar) cutting it and standing up by differential weathering, almost an inch above the general rock surface. |
| 1.2 | 24.2 | Road swings left (east), leaving the road shown on the topographic map, which has had to be abandoned as a result of the formation of Hoover Reservoir. |
| 0.3 | 24.5 | Red Banks Cemetary; the red banks of the Bedford may be seen just beyond the cemetary to the right (south) in the valley of the north fork of Duncan Run. |
| 0.6 | 25.1 | Turn right (south), following blacktop road. This road is not on the Westerville quadrangle, but it follows the township boundary. In valley ahead, cuts have been well grassed, but Berea float may be seen, not far from an outcrop, in the minor gully to the left (east) on the north side and the Bedford shale is poorly exposed on the south side (especially on the left (east) side of the road). Then the road climbs back up onto the till-capped Berea surface. |

To the right (west) in the Lake of the Woods Subdivision, water well drilling has revealed the presence of a small buried valley. Drift here is about 60 feet thick, rather than nearer 25 feet as found elsewhere in this area. This is apparently a small west-flowing tributary of a main north-south buried valley which trends almost parallel to the valley of Big Walnut Creek. This main valley no doubt has many such minor tributaries, much as do modern main streams, but only rarely does well drilling find evidence for them, as in the Lake of the Woods Subdivision. This main stream, which appears to have flowed southward, has been reported from well logs located as far north as one to two miles southwest of Galena and is known to intersect the present valley at Hoover Dam, as recorded by extensive preliminary drilling done there. It actually created an engineering problem at the dam because the buried valley is filled, in the lower part, with glacial gravels, which are very permeable and present a possible subsurface leak for the reservoir water. (All well data and their interpretation, courtesy of Mr. James Schmidt, Division of Water.)

1.6 26.7 Turn right (west) at county line off of Schott Road onto Smothers Road.

0.2 26.9 Begin descent off the Berea escarpment.

0.3 27.2 Note exposure of weathered Bedford shale in road cut to right. Farther ahead on the right is the quarry of the Delaware Clay Company in the Bedford shale, in which may be seen a shale planer (large piece of quarrying machinery with which shale is mined by being planed off in vertical sections).

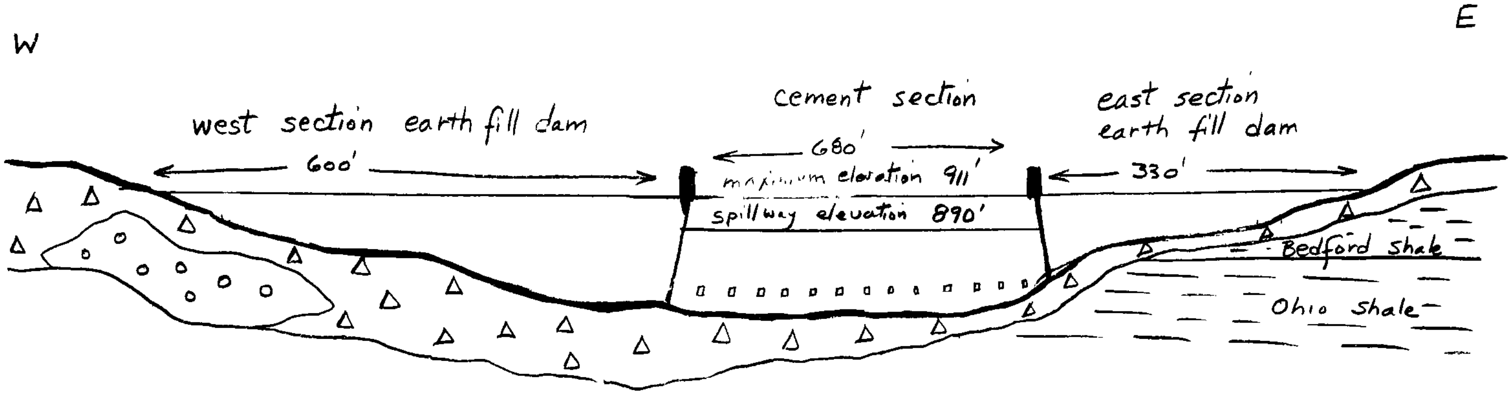
0.6 27.8 Cross bridge over Hoover Reservoir. Note Hoover Dam one and a half miles away to the left (south).

0.3 28.1 Stop sign. Turn left (south) from Smothers Road onto Sunbury Road.

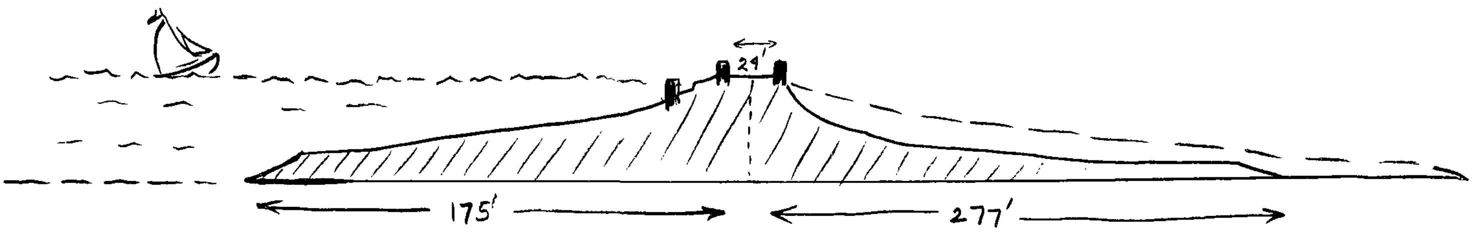
1.6 29.7 <u>STOP 4</u> - <u>Lunch at Hoover Dam.</u>

The Ohio Academy of Science field trip in 1953 stopped to see Hoover Dam, then in the construction stage (see Stop 6 in that guidebook for much data concerning the cost, area, water-holding capacity, and geology relating to this project). The dam is now completed, mainly an earth-filled structure with a central cement spillway. It has dammed Big Walnut Creek so that a lake $8\frac{1}{2}$ miles long has been created, with a surface at 890 feet elevation. This is one of the sources of Columbus' water; the water is transported from this reservoir through a 48-inch pipe to a treatment plant at Morse Road and from thence into Columbus' water mains. Problems in engineering were encountered here because of the presence of weathered shale in the valley bottom (handled by grout holes in bottom of dam and anchoring to solid rock on east side) and of gravel in unconsolidated west bank (handled by extra earth-fill and extra rip-rap on the north side of the dam there). Departure from this stop is planned for 1:30 P.M.

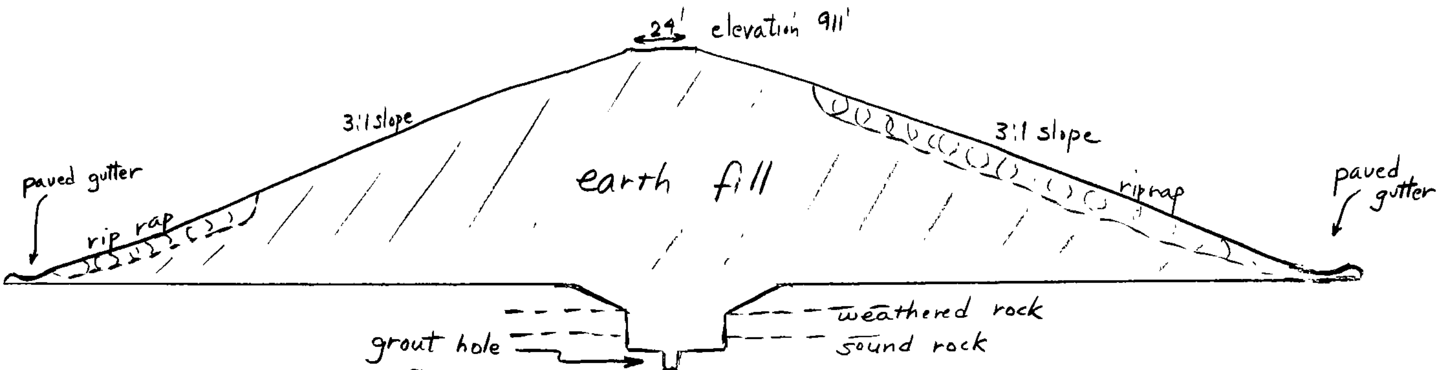
After lunch, turn left (south) and continue south on Sunbury Road.




East-west view of Hoover Dam from south.




Cross-section of central cement spillway.




Cross-section of earth-fill section.

| | | |
|---|---|---|
| 0.4 | 30.1 | Town of Central College. Continue straight ahead (south). The buildings here were once occupied by an educational institution called Central College. This college was moved to Wooster more than 23 years ago and the buildings are now used as a home (private) for the aged and infirm deaf. |
| 1.6 | 31.7 | Traffic light. Turn left (east) off Sunbury Road onto Ohio 161 and immediately park on right, well off of main road. Ohio 161 is well travelled, so use caution. |

STOP 5 - Buried esker. Though commercial gravel (untreated) is obtained from this pit, the surface material throughout the area is till. The thickness of this till cap has varied in the pit from about two to six feet, but the variation over the whole esker in this area is doubtless much greater. No hill at all can be observed in the exploratory excavation in the fill across Big Walnut Creek to the east (seen from mileage 32.0 ahead); it is probably part of the deposit from which the till cover has been washed off.

Gravel hills farther south in eastern Franklin County, which are also called eskers because of their linear shapes and distribution, are also till-capped and probably are of essentially the same age as this deposit. In some places (the Groveport esker and Baker Hill) a red, leached, sticky, clay-enriched zone is present in the upper part of the gravel, directly beneath the overlying calcareous till. Because this zone looks exactly like the modern Fox soil, which develops in gravel which is exposed at the surface today, these buried zones have been interpreted by most people as buried soils or paleosols. The top of the gravel is thus interpreted to represent a past land surface, exposed to soil-forming action during an ice-free interval within the Wisconsin glacial stage. (A similar buried soil was observed at the Keiffer Gravel Pit, Stop 1 on the Ohio Academy field trip in the Springfield area, in 1956). The overlying till throughout western Ohio has been shown by radiocarbon dates to be equal to the entire interval of the classical Wisconsin in Illinois. The older deposit, therefore, which is here gravel, but which also includes till, is referred by Goldthwait to an "early" (pre-classical) Wisconsin substage. (Note that this differs from the interpretation in the 1953 Ohio Academy Guidebook, at Stop 7; this change in interpretation has been made necessary by the results of radiocarbon analyses, which had not appeared at that time. The modern interpretation is well summarized in an article by Goldthwait in the July 1958 issue of the Ohio Journal of Science.)

Gravel exposed beneath till in Rocky Fork valley, east of Gahanna, is presumed to be of the same age as the gravel in the esker, here at Stop 5 and farther south. A few years ago, wood was found in the Rocky Fork gravel which, when dated by radiocarbon means, gave an age of "greater than 37,000 years" (W-263). This gives a minimum age for the deposition of the esker; how much older the esker is, is not clear, but determinations of ages of Early Würm materials in Europe suggest that the actual date of this earlier glacial substage might be around 60,000 years ago. The surface till is part of the deposit left by the "late" Wisconsin glacier which (according to radiocarbon dating) advanced into Ohio about 24,000 years ago, reached its maximum extent about 18,000 years ago, and had retreated out of Ohio by about 13,000 years ago.

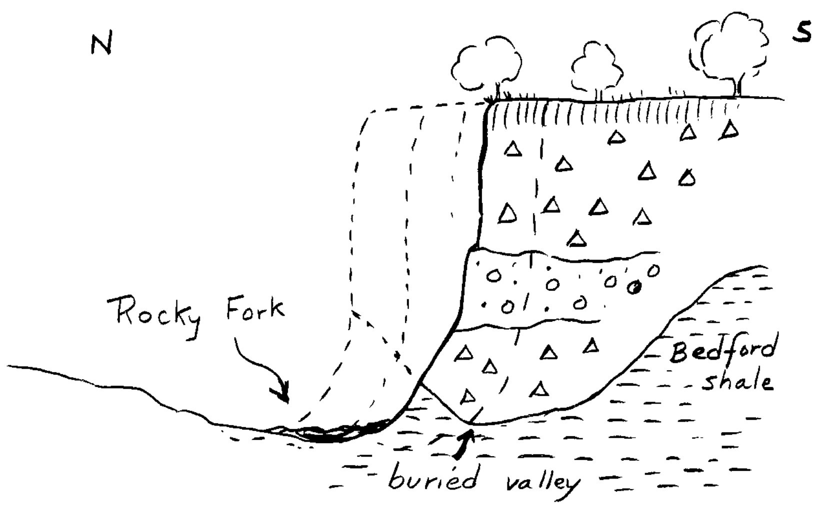
Departure from this stop is planned for 2:15 P. M.

Continue east along Ohio 161 across Big Walnut Creek.

| | | |
|---|---|---|
| 0.2 | 31.9 | At junction with Cherry Bottom road just east of bridge, continue straight ahead (east) on Ohio 161. |
| 0.1 | 32.0 | Hill at right contains gravel (which may be seen, after passing it, by looking back to exploratory digging along its east side). It is not clear, from the digging, whether a veneer of till is present or not, but the proximity of this hill to the buried esker on the west side of Big Walnut Creek, the similarity in coarseness of the gravel in both places, and the location of both these hills along modern valley, all suggest that this hill is also part of the same buried esker system. |
| 0.1 | 32.1 | Fragments of red Bedford shale may be observed along the left edge of the road, just before reaching the Blendon Woods Park entrance, dug up during pipeline excavation. |
| 0.5 | 32.6 | Road climbs Berea escarpment which here marks the outer edge of the Allegheny Plateau. Berea fragments have been exposed here, to the left of the road, as a result of pipeline excavation. |
| 0.8 | 33.4 | Turn right (south) off of Ohio 161. Road lies on the Berea sandstone surface thinly mantled with till. |
| 1.7 | 35.1 | Stop sign. Cross Morse Road and continue straight ahead (south). |
| 0.5 | 35.6 | Note Berea sandstone float in minor gully to left (east). |
| 0.6 | 36.2 | Stop sign. Continue straight ahead (south) across U. S. 62. |

| | | |
|---|---|---|
| 1.0 | 37.2 | Note gravel pit in kame to right (west) through trees. No till is exposed above the gravel in this pit, so it is unlikely that this gravel is of the same age as the buried esker seen to the north, though it is of course possible that a till cover was present and has been washed off. |
| 0.2 | 37.4 | Cross Rocky Fork stream. Note nature of bedrock fragments in stream bed--fragments of shale, mainly Bedford, and of Berea sandstone, the sandstone slabs showing excellent shingling. |
| 0.2 | 37.6 | Traffic light. Turn left (east) onto Havens Corner Road at brick school. |
| 0.3 | 37.9 | Note hummocky nature of land to right. Although bedrock is not deep in much of this township, the presence of this hummocky topography, the evidence of locally thick till in the Gahanna till cut ahead, and the fact that this area lies right on line with moraines mapped to the northeast by Goldthwait and to the south by Conley, all combine to suggest that a small area of end moraine is present here, tucked up against the edge of the Berea escarpment. |
| 0.3 | 38.2 | Pass Rocky Fork till cut, just east of Gahanna where Stop 7 was made on the Ohio Academy field trip in 1953. A thick |

Cross section of Rocky Fork till cut, showing position of buried valley.




section of glacial drift is exposed here above an outcrop of the red unit of the Bedford shale. The drift appears to fill a valley cut in the Bedford shale bedrock, the valley being mostly still buried within the south bank of the stream. As the bank retreats to the south by erosion (at a rate estimated to be about three to five feet per year, according to Goldthwait in the 1953 Guidebook), less and less of the old north side of the buried valley is left (see sketch). The bank has been strongly undermined by this year's floods and is now badly slumped.

The drift that fills this buried valley and forms most of the bank consists of two (?) upper tills and a lower till separated by gravel. It was this gravel from which the wood was obtained that was dated by radiocarbon means at "greater than 37,000 years old" (W-263), a date which probably applies to the entire esker system of eastern Franklin County.

A great deal of data are available for the various units in the glacial section exposed here: the brown surface till, the gray upper till lying beneath the brown, the gravel, and the lower till. This data is in the form of stone counts, pebble orientations, and other information collected year after year by Goldthwait and his students. These results were discussed in the 1953 Guidebook, but may be summarized here as follows:

1. Top brown till - lacks recognizable pebble orientation, has slightly higher percentage of sandstone pebbles, and slightly lower percentage of foreign crystalline pebbles . . . . . . . . . . 8 - 13'

2. Upper gray till - elongate pebbles oriented generally toward southeast, percentage of limestone-dolomite pebbles greater than for any of the other tills here. . . . . . . . . . . . . . . . . . 0 - 24'

3. Gravel - coarser near base, more sandy and cross-bedded near middle . . . . .12 - 21'

4. Lower gray till - contains more shale and foreign crystalline pebbles than other tills . . . . . . . . . . . . . . . 8 - 18'

0.7 38.9 Because parking space at this next stop is limited, it may be necessary to park along main road and consolidate group into as few cars as possible.

Turn left (south) onto private dirt road which crosses open field with split log fences on either side. From here on, we are guests on private property.

0.4 39.3 Note exposures of Berea sandstone, in small creek to left and in small abandoned quarry, now dammed and flooded, to right.

Small ford across creek just ahead is shallow and cement-bottomed.

0.4 39.7 STOP 6 - Rocky Fork Gorge. Drive around circular driveway and park cars as directed very close together so as to allow maximum use of space. Remember that this is a private home; do not drive on the lawn and keep together in walking to the actual outcrop.

Rocky Fork Geomorphic Location. - This gorge is cut in the Berea sandstone as a result of the stream flowing westward (up dip), flowing off of and dissecting the low cuestaform escarpment made by the Berea sandstone, which marks the Allegheny Front, the western edge of the Allegheny Plateau.

Rocky Fork Stratigraphy. - The following section is exposed in the gorge (modified from the Columbus Folio 197, p. 53):

| | Thickness (feet) | Total Thickness (feet) |
|---|---|---|
| Sunbury shale . . . . . . . . . . . . . . | | 10 |
| Carbonaceous, fissile; the lower 2 or 3 inches containing *Lingula*, *Orbiculoidea*, and conodonts; basal contact gradational, but marked by a thin layer of marcasite; only lower part of formation exposed here beneath covering of till. | | |
| Berea sandstone . . . . . . . . . . . . . | | 39 |
| Upper unit: sandstone, quartzose, fine-grained, gray, weathering to yellowish-brown, firmly cemented, medium- to thick-bedded, lenticular and prominently cross-bedded; exposed in vertical valley wall below Sunbury shale. . . . | 18 | |
| Middle unit: interbedded gray sandstone and shale; the sandstone is fine-grained, in layers 1 to 10 inches thick, well ripple-marked, with some layers having a contorted or "rolled" appearance . . | 8 | |
| Lower unit: shale, arenaceous, gray, ripple-marked, containing thin ripple-marked gray sandstone layers; a "concretionary" sandstone layer about 1 foot thick at base; basal contact gradational . . . . . . . . . . . . . . . | 13 | |

| | Thickness (feet) | Total Thickness (feet) |
|---|---|---|
| Bedford shale . . . . . . . . . . . . . . . | | 47 |

Soft, argillaceous, gray, claystone, somewhat arenaceous in the upper part; only a few feet exposed here, but also present in a number of cut-banks down stream from this stop.

The "red shale" unit crops out in Rocky Fork till cut, about 3/4 mile down stream (see mileage 38.2), and farther on down the lower gray shale unit is exposed in contact with the underlying Ohio black shale.

Various stratigraphic features in the Rocky Fork Gorge area illustrate further the characteristics of the Red Bedford Delta. The complete delta section lying between the Ohio and Sunbury black shales is represented, each unit representing a major stage in the depositional cycle of the delta: 1. Ohio shale: the black mud deposition on a marginal shelf in the western portion of the Appalachian trough. 2. Lower gray, middle red, and upper gray units of the Bedford shale: the delta construction southward through the middle of the Ohio Bay, with the subaerial red muds covering the shallow marine gray muds, and in turn being buried by the overlapping gray marine muds during the subsequent period of subsidence. 3. Berea sandstone: the deposition of sand in the shallow sea around the delta beyond the channel deposits of the Ontario River to the north. 4. Sunbury shale: the return of black mud deposition over the submerged delta as subsidence again took place, widening the Ohio Bay northward.

Blacklick Well Log. - A test well was drilled in the quarry at Blacklick, three miles to the southeast of this stop, to explore for limestone a few years ago. The core has recently been acquired by the Ohio Geological Survey for study, but no detailed work has yet been done. The section encountered by the drilling is as follows (information courtesy of Mr. Ralph Bernhagen, Chief, Ohio Geological Survey):

| Formation | Depth of top below surface |
|---|---|
| Cuyahoga formation . . . . . . . . . | 0 feet |
| Sunbury shale . . . . . . . . . . . . | 31 |
| Berea formation . . . . . . . . . . . | 68 |
| Bedford shale . . . . . . . . . . . . | 113 |
| Ohio shale. . . . . . . . . . . . . . | 182 |
| Delaware limestone . . . . . . . . . | 733 |
| Columbus limestone . . . . . . . . . | 734 |
| (Conglomerate in last few feet of core) | |
| Total Depth | 801 feet |

This is the end of the 1959 field trip. We hope that you have enjoyed it. See you next year . . . .

Printed through the courtesy of the Ohio Division of Geological Survey.